USGS-ASPRS Efforts to Quantify the Quality of Lidar Data

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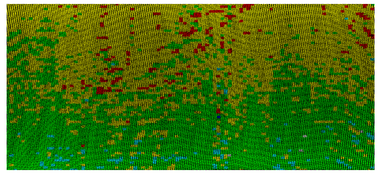
Introduction

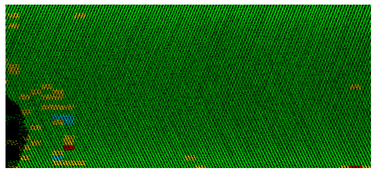
The current lidar data quality assessment methods are not adequate in the reporting of:

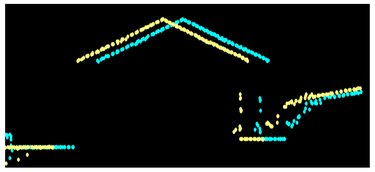
- The quality of calibration of lidar system, which is an essential indicator of the overall quality of data.
- The horizontal accuracy of the data.

The availability of standards are particularly important for large projects such as the proposed 3D Elevation Program (3DEP). Recognizing this, the U.S. Geological Survey has partnered with the American Society for Photogrammetry and Remote Sensing (ASPRS) to promote industry-accepted guidelines to assess the quality of lidar data.

The partnership has created a working group that includes all major lidar instrument manufacturers, data providers, and Government agencies (USGS, National Geodetic Survey, U.S. Army Corps of engineers, National Geospatial Intelligence Agency, etc.)



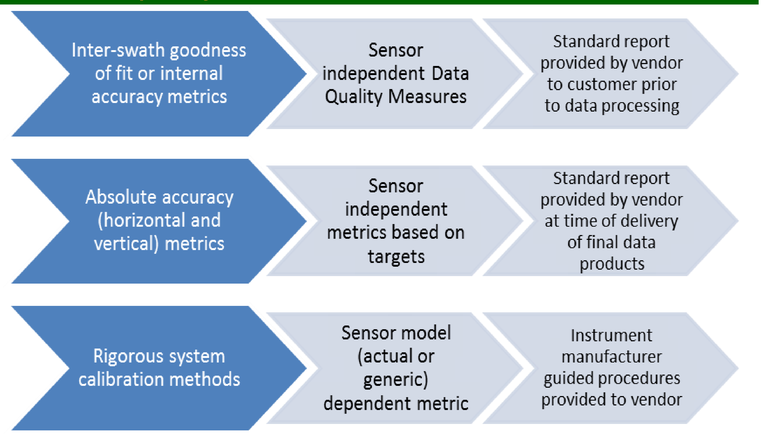




Quality of data collection manifests itself in overlapping regions of different swaths of data.
The two images show a color coded error map in an overlap area.
The top left image exhibits systematic errors with “positive” errors in north half and “negative” errors in southern half.
The lower left image shows a well calibrated data with low uniform errors.
Building roof mapped differently in adjacent swaths due to calibration error. A poorly calibrated instrument leads to poor data quality (Note: Data adjusted for better illustration).

Current Quality Control (QC) practices may accept all three data sets as there is no accepted methodology to quantify this systematic discrepancy.

Lidar data quality assurance framework



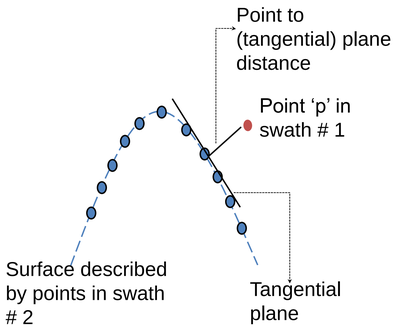
The USGS led working group has designed a three-pronged framework to improve lidar data’s geometric quality.

- Inter-swath quality: Defining procedures for measuring the inter-swath goodness of fit. These include defining three Data Quality Measures (DQMs).
- External quality: Suggesting the use of targets and Ground Control Points (GCPs) on natural surfaces of all slopes to measure the absolute accuracy.
- Rigorous calibration: Suggesting the use of rigorous sensor model based system calibration methods.

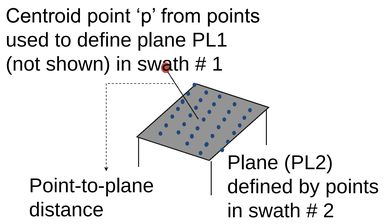
The framework is designed such that the processes for measuring the accuracy (both inter-swath and absolute) of lidar data are independent of the instrument, while calibration is based on its rigorous sensor model.

Lidar data Inter-swath quality

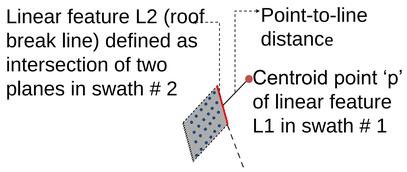
Inter-swath quality is measured in regions where lidar data from multiple swaths overlap. Features in the overlapping regions defined by different swaths should be ideally coincident. The DQMs quantify the deviation from this ideal, and are measures of the internal consistency of data. The DQMs are defined based on the features used for measurements.



DQM over natural surfaces: point to (tangential) plane distance: This measure is calculated by selecting a point from one swath (say point ‘p’ in swath # 1), and determining the neighboring points (at least three) for the same coordinates in swath # 2. A plane is fit to the points selected from swath # 2, and the DQM is defined as perpendicular distance of point ‘p’ to this plane.

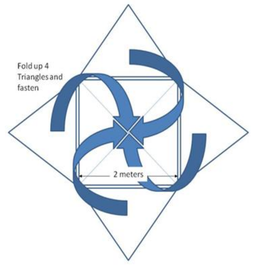


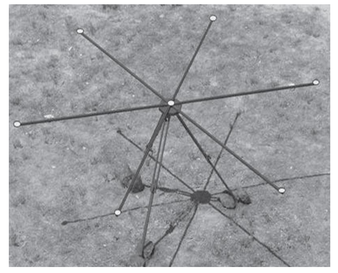
DQM over man-made planar surfaces: Man-made planar features (e.g. roof planes) can be extracted and used for measuring the inter-swath goodness of fit.



DQM over man-made linear features: Linear features (e.g. roof edges), can also be used for measuring discrepancy between adjacent swaths.

Lidar data external quality: using targets





The use of targets is not new to the geospatial industry as they have been used in conventional surveying, photogrammetry and also microwave/SAR based mapping. The first two targets require intensity data also be collected, while the other two targets can work with just the point cloud. Another method of using GCPs surveyed in open terrain (both horizontal and sloping terrain) is being investigated.

Lidar data quality assurance: through rigorous calibration

The above two processes are recommended for QC of lidar data. For Quality Assurance it is recommended that a lidar system be calibrated using rigorous modeling. Rigorous calibration methods are based on determining parameters describing the sensor model completely.

Since many parameters associated with a complete sensor model are proprietary, software to perform rigorous calibration can only be provided by the instrument manufacturer.

The rigorous calibration approach is robust, and since the process is automated the resulting swaths of data are consistent with each other and with external control.

Concluding remarks

- Prototype software that implements DQMs has been developed.
- Currently, DQM software is being tested and results analyzed by ASPRS volunteers.
- The ASPRS Guidelines on Geometric Quality of Lidar Data will incorporate the results of the analysis.
- It is expected that this USGS led ASPRS research will result in an across-the-board improvement in the quality of lidar data processing.
- The new DQMs will provide the geospatial community with the capability to procure and acquire lidar data of higher and quantifiable accuracy.